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ABSTRACT

Chemistry in the Community ("ChemCom") is a high-school level chemistry text developed by the American Chemical Society (ACS) designed for the college-bound student. The purpose of this study was to identify students enrolled in a university-level chemistry course designed for the nonscience major who had experienced the ChemCom curriculum in high school and to evaluate their success. Participants (N=685) from two summer courses (1993 and 1995) were classified into six groups: no prior chemistry, first-year ChemCom, first-year regular, first-year honors, second-year (Chem II), and advanced placement (AP) students. Final course averages for each group were calculated and compared. All groups of students on the average were successful in completion of the course (i.e. had averages above 66%). Results of a t-test indicated statistically significant differences occurred at an alpha level of 0.05, but the ChemCom group did not exhibit a statistically significant difference. Other findings included a decline in enrollment over the experimental period, especially for the ChemCom group. (Author)

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Life after *ChemCom*:

Do they succeed in university-level chemistry courses?

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Life after *ChemCom*:

Do they succeed in university-level chemistry courses?

Abstract

Chemistry in the Community (*ChemCom*) is a high-school level chemistry text developed by the American Chemical Society (ACS) designed for the college-bound student. Funds for its development have been contributed by the National Science Foundation (NSF), ACS, and Kendall/Hunt Publishing Company, but have the efforts of this large collaborative endeavor paid off? The purpose of this study was to identify students enrolled in a university-level chemistry course designed for the nonscience major who had experienced the *ChemCom* curriculum in high school and to evaluate their success. Participants ($n = 685$) from two summer courses (1993 and 1995) were classified into six groups: no prior chemistry, first-year *ChemCom*, first-year regular, first-year honors, second-year (Chem II), and advanced placement (AP) students. Final course averages for each group were calculated and compared. All groups of students on the average were successful in completion of the course (i.e., had averages above 66%). Results of a *t*-test indicated statistically significant differences occurred at an alpha level of .05, but the *ChemCom* group did not exhibit a statistically significant difference. Other findings included a decline in enrollment over the experimental period, especially for the *ChemCom* group.

Objective

Chemistry in the Community (*ChemCom*) is a high school-level chemistry text developed by the American Chemical Society (ACS) designed for the college-bound student (Raber, 1995). Funds for its development have been contributed by the National Science Foundation (NSF), ACS, and Kendall/Hunt Publishing Company, but have the efforts of this large collaborative endeavor paid off? This study sought to identify students who had experienced the *ChemCom* curriculum in high school and to track their success in a traditional university-level introductory chemistry lecture course designed for the nonscience major. The purpose of this study was to address the central question: Are students, whose only chemistry course in high school was *ChemCom*, prepared for a university-level chemistry course designed for the nonscience major? The word "prepared" is used in this study to the extent that these students will experience academic success in this nonscience majors' chemistry course at the average C-level or above.

Significance

The *ChemCom* curriculum stresses the development of problem-solving skills and scientific literacy (Nelson, 1988), and has been touted as a non-traditional approach to teaching

high-school chemistry. Several studies (Heydrick, 1990; Martin, 1993; Moore, 1991; Smith & Bitner, 1993; Sutman & Bruce, 1992) have addressed the appropriateness and effectiveness of the *ChemCom* curriculum during its development and have followed its implementation at the high-school level, but no published studies were identified which addressed the success of these high-school students in university-level chemistry courses. Smith and Bitner (1993) reported that there were no significant differences between the formal operational ability of students enrolled in *ChemCom* versus a traditional chemistry course as determined by the results obtained from scores on the GALT (Group Assessment of Logical Thinking). but we as researchers have been remiss in our failure to follow these students into the university setting leaving part of the picture unfinished. This study reports findings on data gathered from student evaluations over a time span of three years from two, five-week summer school university-level courses; that is, the same introductory-level chemistry course (same instructor) offered in the first summer term of 1993 and 1995.

Theoretical Base

Development of *ChemCom* began in 1980 with the first edition being published in 1988 and the second edition in 1993. The original intents of the authors were to develop a course for students in grades 10, 11, and 12 who were planning a career in a nonscience and non-engineering areas (Heydrick, 1990), and to address the urgency for scientific literacy among students (Moore, 1991). Also, the text was written to address the needs of the lower-reading level chemistry student in grades 10-12 (Sutman & Bruce, 1992). The issue-oriented approach according to Heydrick (1990) may not only enhance scientific literacy, but may also promote positive attitudes among students enrolled in high school chemistry courses. Martin (1993) published a curriculum analysis which yielded an evaluation of the topics taught, and reported that the depth of the curriculum was not substantially different from that of a traditional high-school chemistry course. Students who participated in the pilot testing of *ChemCom* were also evaluated on their ability to apply knowledge learned. Sutman and Bruce (1992) reported that *ChemCom* students significantly outperformed students from a more traditional college preparatory course in

applied knowledge. Results from the development and field testing of *ChemCom* indicated that this course is a "valid, highly functional instructional program when used with those secondary-level students for whom it was designed" (Sutman & Bruce, 1992, p. 566). From these results it appears that the *ChemCom* curriculum has not deterred students from learning significant chemistry content and it may serve to motivate them more than a traditional chemistry course. The question remains--will students who attend a traditional lecture-oriented, nonscience major university-level chemistry course succeed?

Design and Procedure

Students (n=685) enrolled in two university-level chemistry courses designed for the nonscience major were surveyed to determine their high-school background in chemistry. From the data collected on this survey, students were grouped into the following six classifications reflecting the most advanced level of chemistry completed by each student in high school (grades 9-12): first-year *ChemCom*, first-year regular, first-year honors, second-year (Chem II), second-year Advanced Placement (AP), and no prior chemistry course. Students' final course averages were calculated for the summer classes of 1993 and 1995. Course averages for the six groups were compared using a one-factor analysis of variance (ANOVA) to determine if the groups' means were significantly different from one another. Tukey's HSD evaluation was performed to determine where *highly* significant differences between groups occurred. Also, comparisons were made between the groups' means and the overall average of both classes using a two-tailed *t*-test.

The summer school classes were chosen for this study because of their uniqueness. First, there is a larger concentration of *ChemCom* students in the summer provisional program than during the longer fall and spring semesters. Second, the students enrolled in the provisional program are highly motivated to succeed, because failure to pass or a withdrawal from the course forfeits your fall enrollment at the university. The third reason for the selection of these particular classes is that the range of students (i.e., all groups from no prior knowledge of the course to

those that claim to have had AP chemistry) one would typically find in the fall and spring semesters exists.

Findings

Distribution of subjects ($n = 685$) enrolled in the combined sample (i.e., classes from the summers of 1993 and 1995) were grouped according to their high-school background and final course averages (see Table 1). Over both five-week periods, 15 students withdrew from the classes (nine from the 1993 class and six from the 1995 class). The mean for the two-year study based on the students' averages who completed the course ($n=670$) is 75.0% (middle C) with a standard deviation of 11.8. The range of averages covered 79.4 percentage points from 20.5 to 99.9%. The grades (A-F) were assigned based on the following percentages of the total possible points for each class: F's (0-59.4), D's (59.5-69.4), C's (69.5-79.4), B's (79.5-89.4), and A's (89.5-100).

Table 1: Distribution of Letter Grades for Students with Different High School Chemistry Backgrounds

Groups	A	B	C	D	F	W	Totals
None	1	9	12	15	15	5	57
<i>ChemCom</i>	1	7	12	10	4	0	34
1st-year, Regular	25	120	141	69	27	6	388
1st-year, Honors	19	40	56	20	6	0	141
Chem II (2nd-year)	8	7	7	3	6	1	32
Advanced Placement	8	7	5	2	0	0	22
Missing Data	0	4	2	2	0	3	11
Totals	62	194	235	121	58	15	685
Percentages	9.1	28.3	34.3	17.7	8.5	2.2	100.0

A one-factor ANOVA test was performed on the mean data ($n=662$) from the grouped students' class averages (see Table 2). (Only 662 of the 670 students who received a grade in the courses were available for the ANOVA analysis because the researcher was unable to obtain the high-school background of eight students who completed the class.) Table 2 reports the calculated F -value indicating that there was a significant difference at the .05 alpha level. Since the data produced a statistically significant difference between the groups of students, a post hoc analysis was performed. Tukey's HSD evaluation was chosen for the post hoc analysis since all possible comparisons were made, and also two-tailed t -tests were performed using the overall mean of 75.0% (see Table 3). Tukey's HSD evaluation indicated no significant differences between the groups; however, when each group was compared to the overall mean significant differences were seen. Group means from students who claimed to have no prior chemistry course experience, first-year honor students, and AP students differed significantly from the overall mean.

Table 2. ANOVA Table to Assess Students' High-School Background on Class Averages

<u>Anova Table</u>					
Source of Variation	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F*</i>	<i>p</i>
Between groups	5	7064.223	1412.845	10.912	<.05
Within groups (error)	656	84934.056	129.473		
<hr/>					
Total	661	91998.279			
<hr/>					

$$*F_{.05(5,656)} = 3.7$$

Table 3: Two-tailed *t*-test evaluation of Student's Background with Overall Mean (75.0%)

Groups	<i>df</i>	Means	<i>t</i> -values	Significance (<i>p</i> <)
None	51	66.531	-4.65	.0001
<i>ChemCom</i>	33	71.817	-1.734	NS
1st-year Regular	381	74.791	-0.365	NS
1st-year Honors	140	77.408	2.562	.05
Chem II (2nd-year)	30	77.077	0.867	NS
Advanced Placement	21	84.587	4.578	.001
Missing Data	7	76.205	0.377	NS

Limitations

The reproducibility of this study is limited to the students' understanding that they participated in a high-school chemistry course which followed the *ChemCom* curriculum. Also, there is no guarantee that the course taught was that intended by the authors/developers, and obviously there can be no control to account for the fact that the students attended many different high schools in the USA and across the globe, consequently being taught by many different high school chemistry teachers. Even though a sample size of 685 existed, only a relatively small sample, 34 students (5%), claimed that *ChemCom* was the highest level of chemistry they experienced in high school. Some researchers may also question the validity of comparing students of different backgrounds against the same criteria for success, but until further research is completed regarding the success of *ChemCom* students at the post-secondary level, the question of their success remains. This study only represents one part of the whole picture.

Conclusion

All groups of students, regardless of their high school background in chemistry, on the average passed (i.e., had averages greater than 60%). However, by the criteria established for

the definition of "success", those students who claim to have had no prior academic chemistry course were on the average not successful in completion of this particular university-level chemistry course designed for the nonscience major. This was the only group of students which failed to achieve at an average level of C or higher. Statistically significant differences were seen for the group with no prior chemistry course and for those who had been exposed to a first-year honor's course and an Advanced Placement course; however, statistically the *ChemCom* group exhibited no significant difference from the overall mean, 75.0%. Based on the criteria established for success in this study, it can be stated that the *ChemCom* students did succeed at or above the average level in this researcher's introductory chemistry course.

Another point of interest to this study, is that in 1993, 26 of the 388 students (6.7%) were classified as members of the *ChemCom* group and only 8 of the 297 students (2.7%) were reported as members of the 1995 *ChemCom* group. In other words, in this study only 5% of the sample studied claimed to be members of the *ChemCom* group and the enrollment percentages declined from 1993 to 1995. Illman (1993) reported that between 1990 and 1992, that national enrollments in chemistry rose by 4%, female enrollment had increased by 4% since 1982, and between the years 1982 and 1990, black enrollment has increased by 19% along with an increase in Hispanic enrollment by 24%. Unfortunately, this researcher found that the enrollment between years 1993 and 1995 declined by over 13%, and the *ChemCom* student group was responsible for 30% of the decrease.

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Life after *ChemCom*:

Do they succeed in
university-level
chemistry courses?

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St. Louis, MO
April 2, 1996

Defining *ChemCom*

Development began in 1980
First edition: 1988
Second edition: 1993

Developed by: ACS
Designed for: college-bound students,
grades 10-12, planning a career in
nonscience and nonengineering areas

Funded by: NSF, ACS, Kendall/Hunt Pub.

Stresses: development of problem-solving
skills and scientific literacy, and
addresses the needs of the lower reading-
level student.

Content: nontraditional (issue oriented)
approach to high school chemistry.

Depth of curriculum: similar to more-
traditional courses.

Purpose

Are students, whose only
chemistry course in high
school was *ChemCom*,
prepared (i.e., will they succeed
at or above an average level)
in a university-level chemistry
course designed for the
nonscience major?

Population

n = 685 (two classes)

Course:
summer school, provisional program
(major research institution in southwest)
Introduction to Chemistry I
(for nonscience majors)

Instructional methods: large-group lecture,
traditional format with classroom
demonstrations appropriate for large-
lecture halls, standard topics covered.
two TAs and one instructor per class,
graded homeworks, instructor-generated
and graded exams (not multiple choice)

Justification for Choices

Why summer school, provisional program?

1. Students have one thing in common--
they want to go to UT-Austin and they
have not been regularly admitted--
high motivation to succeed!
2. Captive audience--if they drop the class,
they forfeit enrollment at UT-Austin.
3. The whole range of students from those
who have never had any prior chemistry
to those who have had AP chemistry
exists--typical of any long-semester class.
4. Larger concentration of *ChemCom*
students in summers than in the longer
terms.

Groups

first-year *ChemCom*
first-year regular
first-year honors
second-year (Chem II)
second-year AP
no prior chemistry

Table 1

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Groups	A	B	C	D	F	W	Totals
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Table 2

Two-tailed t-test evaluation

Groups	df	Means	t-values	Sig (p <)
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AP	21	84.587	4.578	.001
Missing Data	7	76.205	0.377	NS

n=670 (15 dropped course)
Overall mean: 75.0% (middle C), 11.8 so
Range: 20.5% to 99.9%.

When ChemCom students' average was
compared to average of all other students,
no statistically significant difference was
found.

Limitations

1. Reliability of students remembering that they used the ChemCom curriculum.
2. The ChemCom course they say they had was that intended by the developers of the curriculum.
3. Many different high school chemistry teachers.
4. Validity of comparing students of different backgrounds against the same criteria for success.
5. Small sample size of ChemCom students.
6. Limited to one instructor at the university level.

FURTHER RESEARCH IS NEEDED!

Concerns

1. Are there truly differences between ChemCom and other more-traditional curricula?
2. Are we too concerned with development of curriculum and not enough with preparation of future teachers?
3. Should we label high school students as potential nonscience/nonengineering majors?
4. Is it "fair" to compare ChemCom students in a traditional chemistry class at the university level to other students who have already experienced a more traditional curriculum?
5. If we raise our state/national standards to include that all students should take at least one-year of chemistry, what sort of curriculum should this be? (Should it be assumed that all high school graduates who have taken chemistry have had equivalent experiences?)

Conclusions

1. ChemCom students are succeeding at the average level in this introductory chemistry course for nonscience majors.
2. On the average, they outperform students who claim to have no prior background in academic chemistry, but are below all other students who claim to have taken another high school chemistry course.
3. There was a 30% decline in enrollment of students from 1993 to 1995 who claimed to have taken ChemCom.